observed in 6 and 8 measurements (total of 26.9%), respectively, but only 2 measurement were over 10%. Four of the six measurements on the anal verge showed difference of 5% or more between the calculated and estimated dose.
Conclusions: With high dose gradients in VMAT treatments it is essential to know the correct position of TLDs in order to properly analyze the results of in-vivo dosimetry. This new procedure seems dealing with this issue, allowing validating and monitoring doses delivered to patients.

PO-0786
Retrospective assessment of the clinical impact of errors detected in patient specific IMRT QA: a validation study
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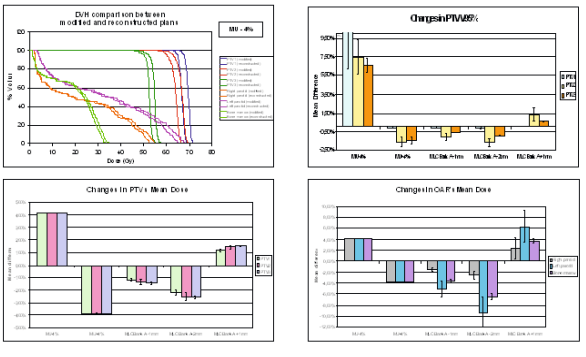
Purpose/Objective: The clinical importance of the discrepancies detected in pre-treatment IMRT QA is often difficult to interpret. This seems to be possible by using a recent commercial software, **3DVH** (SunNuclear, USA), that relies on field QA data to reconstruct a 3D dose distribution in the patient. A study is planned in our Institute to compare IMRT calculated dose distributions to the *delivered* ones reconstructed from QA results. In this work, we present the feasibility study dealing with the validation of the used software and methods.
Materials and Methods: The validation study introduced deliberate errors in a sample of clinical plans to simulate delivery/calculation errors (*modified plan*). Then the error-free beams were used to generate *virtual* planar QA measures and input to SNC Patient software, which generates a PDP *(Planned Dose Perturbation)* file containing information about QA and calculated doses. The DICOM RT files together with the PDP file were loaded into the 3DVH software to reconstruct the error-free 3D patient doses by perturbing the modified plan. MU delivery errors of ±4% were simulated in the TPS. MLC errors were simulated by opening and closing leaves of one MLC bank by 1 mm or 2 mm. The comparison between the 3DVH reconstructed dose and the original unmodified plan is performed in terms of the main DVH parameters of PTVs and OARs. Finally, the 3DVH software was applied to a sample of 10 head-and-neck (H&N, highly modulated due to simultaneous delivery of different doses to 3 PTVs) clinical plans and relative pre-tx QA performed with a diode array (Mapcheck2, SunNuclear, USA). The 3D **γ**-matching rates of the reconstructed plans are compared with the **γ**-passing rate of per-beam planar measures to detect possible correlations.
Results: Fig. 1 shows the impact on the main DVH parameters of the simulated errors, as given by the 3DVH software. As expected, dose (MU) errors have a larger impact on PTVs than changes in MLC positions. In particular, a ± 4% change in MU is associated to a change in the PTVs mean dose of + 4.16 ± 0.01% and -3.84 ± 0.01%, respectively, suggesting a slight bias of 0.2%. Similar results have been obtained for OARs' mean dose, while the impact of MLC error results more important than MU change. As for the capability of the 3DVH software to accurately reconstruct the original plan from the modified plan by using the *virtual* planar measures, all results give an almost perfect match of the 2 plans. Small differences are found only for very small volumes such as parotids. Finally, the application of 3DVH to our 10 H&N clinical sample has shown no significant correlation between the γ passing rates of single beam QA and the 3D matching rate of the reconstructed plan; better correlation is found with the minimum value of γ passing rates obtained in QA per-beam measures.



Conclusions: Validation of 3DVH software against TPS has shown good results. Application to clinical plans using real QA data shows that the dosimetric discrepancies detected in individual field QA are not correlated to the γ of the reconstructed plan.

PO-0787
Clinical validation of Gated RapidArc using aS1000 Electronic Portal Imaging Device
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Purpose/Objective: The purpose of the study is to clinically validate the Gated dose delivery for mobile targets with VMAT using Electronic Portal Imaging Device (EPID).
Materials and Methods: The advantage of Gated RapidArc (G-RA) technology is that it reduce the margin of Internal Target volume (ITV) which reduces the dose to OAR's adjacent to the mobile tumours. G-RA was delivered using the Varian Real-Time Position Management (RPM) system which uses external retro reflective infrared markers to generate gate-open signals of different durations. To assure the proper dynamic dose delivery and MLC position of G-RA treatments, we selected five lung cases and RA plans were created in Varian Eclipse(v10) Treatment Planning System (TPS). Verification plans were generated using portal dosimetry and Portal Dose Prediction Algorithm (PDIP v10) is used to predict the portal dose at the isocenter. All plans were executed in Clinac-iX treatment machine and portal dose images were acquired using EPID, while Infrared reflecting box is periodically moved to provide gating signal for RPM system.To evaluate the accuracy of dose delivery, measurements were performed for different duty cycles (80%, 50% & 20%) and were compared with the portal doses of non-gated RA of the same plan. Earlier the non-Gated RA plans were compared with the TPS predicted portal dose. Area gamma and dose difference was analyzed in portal dosimetry workspace in Eclipse for the criteria 2mm Distance to Agreement (DTA) & 2% Dose Difference (DD) and 3mm & 3%.MLC Dynalog files were analyzed and expressed as root mean square (RMS) of the deviations of individual leaves during treatment delivery.
Results: The accuracy of gated RapidArc dose delivery is compared against the non gated RapidArc delivery using electronic portal imaging device. The average area gamma less than 1 for duty cycles 80%, 50%,& 20% were 99.84(±0.19), 99.5(±0.29), 87.52(±1.57) for 2mm DTA & 2% DD and 100.0(±0.0), 99.98(±0.05), 98.96(±0.87) for 3mm DTA & 3% DD respectively. Average of maximum error root mean square for all MLC positions were 0.074mm (±0.0059), 0.072mm(±0.0060), 0.067mm(±0.0033) for 80%, 50% & 20% duty cycle respectively.

No. of Patient	Gated RA Vs. Non Gated RA									Non Gated RA Vs.TPS		
	80% Duty Cycle			50%Duty Cycle			20%Duty Cycle					
	Avg.Area Gamma(%)		Max.Error RMS of MLC (mm)	Avg.Area Gamma(%)		Max.Error RMS of MLC (mm)	Avg.Area Gamma(%)		Max.Error RMS of MLC (mm)	Avg.Area Gamma(%)		Max.Error RMS of MLC (mm)
	2mm & 2%	3mm & 3%		2mm & 2%	3mm & 3%		2mm & 2%	3mm & 3%		2mm & 2%	3mm & 3%	
1	99.9	100.0	0.068	99.6	100.0	0.066	85.6	97.5	0.065	90.4	96.0	0.079
2	99.9	100.0	0.082	99.7	100.0	0.079	87.3	99.7	0.071	96.3	99.2	0.076
3	100.0	100.0	0.076	99.0	100.0	0.075	86.5	99.4	0.067	90.3	96.7	0.079
4	99.5	100.0	0.077	99.5	99.9	0.076	88.9	99.3	0.07	95.2	98.3	0.076
5	99.9	100.0	0.069	99.7	100.0	0.066	89.3	98.9	0.063	94.6	97.2	0.078
Average	99.84	100.0	0.074	99.5	99.98	0.072	87.52	98.96	0.067	93.36	97.48	0.078

Conclusions: Gated RapidArc delivery validated using EPID and results exhibits that there is good agreement between delivery of G-RA and non gated RapidArc. For fast, accurate and its highspatial resolution, EPID can be used as a verification tool for gated RA delivery.

PO-0788
GafchromicÆ EBT3 for pre-treatment IMRT verification: comparison among different analysis approaches
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Purpose/Objective: Radiochromic films are recognized to be suitable for patient specific QA in IMRT treatments verification because of high spatial resolution, near-tissue equivalence and weak energy dependence. Challenges in radiochromic films dosimetry using a multichannel flatbed scanner, are related to uncertainties due mainly to scanner non-uniformity and film thickness difference within films

area. Different analysis techniques have been proposed to increase the accuracy of radiochromic films dose distribution measurements.
The aim of this work is to compare the results obtained whit different analysis techniques in assessing dose distribution for IMRT photon beams pre-treatment verification.
Materials and Methods: Gafchromic®EBT3 films have been calibrated irradiating 5x5 cm film pieces with a 6 MV linac photon beam at different dose levels in a range from 10 to 400 cGy at 5cm depth in PMMA phantom and SSD 95 cm. Then 40 IMRT clinical beams have been verified by gafchromic films with the same irradiation setup. Films have been scanned with a Epson 10000XL flatbed scanner 24 hours after irradiation and dose distributions have been assessed using an home-made software. Our software allows to perform analysis in 4 different ways: red channel (R) analysis, red channel analysis with the correction for the scanner non-uniformities (RC), the red/blue channels (RB) analysis and the 3 channel (RGB) analysis using formulas proposed by Mayer (Med. Phys. 2012). The films absolute dose distributions obtained have been compared with the calculated ones by means of 3%(local)/3mm gamma analysis.
Results: Gamma analysis pass rates obtained with RGB analysis (98.0±2.7) are higher than pass rates obtained with all the other analysis approaches, while the lowest mean pass rate (88.9±13.3) has been obtained, as is was expected, evaluating the dose distribution using the R analysis. Comparing RB and RC techniques, the last one provide better results (96.5 ± 3.4 vs 94.1 ± 7.2). Moreover standard deviations of mean values are inversely proportional to gamma pass rates meaning that methods giving higher pass rates are also more consistent.
Conclusions: The newly proposed three channels analysis allows to take in account different source of inaccuracy increasing the gafchromic films capability to measure IMRT dose distributions.

PO-0789
MLC leaf position stability of a 160-leaf MLC measured using EPID.
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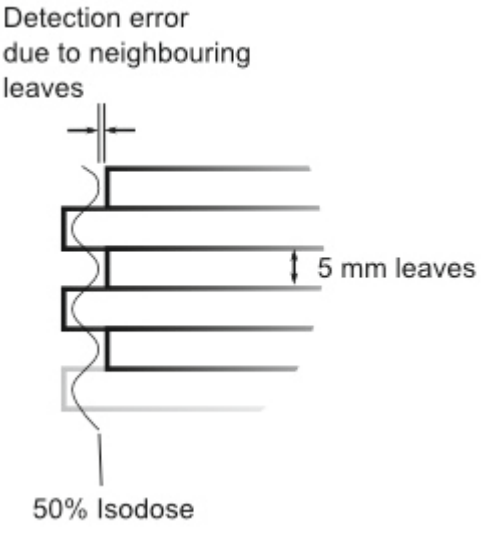
Purpose/Objective: Verification of the position of MLC leaves is an essential part of routine linac quality assurance. This is particularly true when more advanced treatment techniques such as VMAT/RapidArc and IMRT are used. These treatments are typically built up out of smaller, possibly abutting fields, amplifying the effect of any mispositioning of the leaves. The Elekta Agility MLC (Elekta, Crawley, UK) has 160 leaves, with 0.5 cm effective leaf width in the isocentre. It comes with an automated tool to calibrate the leaf position offsets and motion gains. This is a 'black-box', and direct control over leaf positioning is no longer possible, but independent verification is still essential. The aim of the research presented was twofold: 1. To test the MLCSoftEPID software (PTW, Freiburg, Germany) as a quick tool for routine MLC QA, as an alternative to detector arrays or film. 2. To test the positioning stability of the Elekta Agility MLC.
Materials and Methods: An Elekta Synergy linac fitted with an Agility MLC was used. The EPID used was an IviewGT amorphous silicon 1024x1024 pixel EPID, with a 41x41 cm detection area (Perkin-Elmer, Waltham Massachusetts, US). MLCSoftEPID software was used for analysis. This software package requires a standard set of EPID images to be acquired for accurate alignment of the coordinate system of the EPID panel in relation to the linac collimator, followed by a series of strip images from which the leaf positions are then determined, analogous to a picket-fence test. Measurements were compared to our institute's standard SLA-48 (PTW, Freiburg, Germany), a linear array of ionization chambers mounted on a stepper motor. To test whether the measurement of a leaf's position is influenced by the position of neighbouring leaves, images were also made with all odd-numbered leaves intentionally offset by 2 mm compared to even-numbered leaves. In this case, the 50% dose level is no longer directly beneath what would normally be considered the leaf position, due to the nonzero size of the point spread function (see figure). Positioning accuracy for each leaf was tracked biweekly over a period of multiple months.



Results: A routine leaf position QA check using MLCSoftEPID can be done within 10 minutes. Consecutive leaf position measurements using the EPID were found to be reproducible within 0.1mm every time, comparable to or better than traditional alternatives, and agree with conventional SLA-48 measurements within 0.3 mm. Over the 3 months during which leaf stability was measured, all individual leaf positions of the Agility deviated by less than 0.2mm. A non-negligible effect caused by a mispositioning of neighbouring leaves on the position of a leaf as measured by EPID was found. The size of this effect is on the order of 25% of the neighbouring leaf's offset.
Conclusions: The leaf positioning stability of the Elekta Agility is within 0.2mm, over a 3 month period half a year after installation. The MLCSoftEPID software is a useful alternative to current methods of leaf positioning QA used in our institute.

PO-0790
DVH measurements for VMAT
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Purpose/Objective: Due to the complexity of volumetric modulated arc therapy (VMAT), new verification techniques are required. Some new systems allow calculation of DVHs from the measured dose distribution. In this feasibility study we compare this feature in the commercially available 3DVH option of ArcCheck (SunNuclear) with the EPID based 3D dosimetry approach that was developed by the NKI-AVL in Amsterdam and that is being tested in our hospital.
Materials and Methods: For two different clinical VMAT cases (prostate & oesophagus) planned with MONACO (Elekta) we measured the clinical treatment plans on a cylindrical phantom with ArcCheck and a rectangular phantom with EPID dosimetry at a Synergy (Elekta) linac. ArcCheck translates deviations measured by the diodes at the outer boundary of the phantom to deviations in the delivered patient dose.The EPID dosimetry uses a back projection algorithm to convert doses measured at the EPID to 3D doses inside the patient or phantom. To study the sensitivity of both methods, two types of delivery errors have been introduced in the delivered treatment plans. Systematic errors in the leaf position calibration of 0.5, 1, 1.5, and 2mm (open or close) and fixing leaf positions during treatment (of 1 or 2 leaves). We have compared the gamma-statistics (3%/3mm) and the measured and planned DVHs.